Instream measure	Explanation	Other comments
Overland flow pathways of contaminants (sediment, phosphorus and faecal) – All waterbodies in zone –		
Identify and map critical source areas (CSAs)	Information gathering and spatial mapping of CSA locations. The identification of CSAs is required under Matrices for Good Management (MGM) and associated Farm Environment Plans (FEPs). However, this is restricted to the on-farm scale and it would be beneficial to have a wider record and inventory of CSAs on a catchment scale. This will enable more effective management and control of what are likely to be the primary contributors of surface contaminants in waterways in the Waimakariri Zone.	Land management practises are generally dealt with in a parallel work streams. Improved land management will likely have the greatest impact on reducing contaminants entering waterways. Overall, instream solutions will only go part the way to meeting WWZC outcomes. Reducing the source of contaminants is a priority step for preventing the problem. For example, sediment input must be controlled for first before considering the removal of legacy sediment already instream. Doing each in parallel will just make instream sediment removal less effective because it will be replaced by influxes of new sediment from upstream sources. Riparian planting will help buffer streams, but there are trade-offs for what to plant. Native vegetation will provide good habitat potential but some studies suggest that this will be preceded by some bank collapse before the channel widens and banks stabilise. Rank grasses have different nutrient filtering abilities to tree species etc.
Effectively manage critical source areas (CSAs)	Grazing and other stock activity should be effectively managed by using methods that avoid vulnerable CSAs at times of high risk. Such methods include: excluding stock from CSAs until soil moisture content is appropriate (i.e. not wet); only allowing grazing access within ephemeral flow paths for short periods of time to suppress weed growth; erosion and sediment control of fields (including silt fences); not cultivating at vulnerable times (e.g. high rainfall); and fencing off winter grazing. There is a wealth of literature and research on effective CSA control (e.g. Orchiston et al. 2013). The management of CSAs is accounted for under MGM and FEPs; but it is imperative that these processes are well monitored and the rules enforced using the auditing process. Educating landowners on effective management and improving their skills will be a key component to success.	
Stock exclusion from all permanently and intermittently flowing waters with <u>effective</u> fencing setbacks	Stock exclusion should take place on all perennial and intermittent streams. Intermittent streams are major source points for contaminants entering downstream reaches. What "effective" means in terms of fencing setbacks is a case-by-case scenario dependent on the nature of the waterway being fenced and how vulnerable it is to contamination from the surrounding land characteristics and land use practises. The real question when determining a setback is "what are we trying to manage?" For example, is it stock exclusion, bank protection, or nutrient filtering and assimilation? For this reason, it is difficult to place a determined setback distance for all stream reaches and/or types on a wider scale. Larger setbacks do result in a greater level of stream protection and offer a greater buffering potential for contaminants entering waterways.	

Instream measure	Explanation	Other comments
	Stock exclusion and bank protection should be considered as a bare minimum for determining setbacks at a zone-wide scale. Specifically, fences should be erected back from the top of the stream bank to prevent bank damage and erosion. Bank erosion is a large contributor to instream sediment loads. In areas of increased vulnerability, the definition of effective changes. In these areas (e.g. CSAs), fencing setbacks will need to be greater to allow for a greater buffering potential of land contaminants. Effective riparian planting may be critical for these vulnerable areas.	
Sediment accumulation – Lowland spring-fed waterways –		
Initiate deposited sediment monitoring	There are many gaps in empirical data for the zone. Both the extent of the sediment issue and the effectiveness of any management techniques needs to be monitored.	Sediment sources and inputs must be addressed before proceeding with removing instream legacies. A top-down approach (i.e. headwaters to downstream reaches) will be the most effective management technique. The question of "what is the natural state of each stream bed" must also be asked. It is presumed that most spring-fed streams in the Waimakariri Zone are gravel-bedded and therefore require sediment removal. If there are any streams that contain a naturally silty bed, it is important ensure that this is the state it is restored to (i.e. don't keep digging for gravels). Ultimately, the purpose of sediment removal is to remedy the legacy of past land use effects. A two-stage channel approach has been trialled by the CAREX group and have been used elsewhere overseas (see Hudson 2017 Cam River report for details). It essentially creates an artificial flood plain, but there is a shared concern from the expert panel over the viability of this technique. Many trials have been limited to heavily modified drains and it may only result in minor improvements. Reductions in sediment input is correlated with reductions in phosphorus. This is because phosphorus binds to the sediments.
Fencing for stock exclusion using effective setbacks across entire length of network	Fencing to prevent localised bank failure and promote bank stabilisation. See stock exclusion discussion above under *"Overland flow pathways of contaminants"*.	
Riparian planting for bank stabilisation	Plant roots help stabilise banks, and prevent bank erosion and collapse. They also have the associated benefits of increasing plant nutrient uptake and assimilation. Planting strategies (including what species to plant) must be carefully selected based on preferred function and other indirect benefits to instream ecosystem health.	
Channel and bank engineering to prevent sediment accumulation and ongoing bank erosion	Many of the streams in the Waimakariri Zone are extensively channelised and straightened. Channel engineering that will ensure increased sinuosity has the potential to alter flow profiles and promote more "naturalised" waterway characteristics. Bank contouring and rebattering has been used with some success elsewhere. These techniques can also create a more naturalised state and promote bank stability.	
Active removal of instream legacy sediment	At some stage in the management process, active sediment removal must be employed. This is because lowland spring-fed streams do not experience the flushing flows necessary to remove existing bed sediment. A big question is, "how long do we wait before we actively remove the sediment?" Active sediment removal techniques can be very destructive to existing instream habitats, can re-suspend sediments, and kill fish and other instream fauna. Another question is, "how long will it take the streambed to refill with sediment once	

Instream measure	Explanation	Other comments
	it is removed?" For this reason, addressing sediment inputs by remedying CSAs and other land-based sources should be the top priority. Common ways for removing legacy sediment is by using dredges and diggers, but there should be an allowance for new technologies. Sand wands can also be used but are often less efficient. Disturbing and disposing of contaminated sediments is also an area of concern and must be dealt with carefully.	
Sediment traps	Instream sediment traps are an option, but a lower priority (or perhaps even a last resort) when considering the alternatives listed above. There are questions around the viability of the technique. Stream reaches will have to be sacrificed, contaminants in sediments may be disturbed during removal, and traps will continue to fill over time (perhaps even rapidly). Ongoing maintenance is required to remove sediments from traps, which comes with associated risks as detailed under "*Active removal of instream legacy sediment"* above. "Turning off the sediment tap" remains to be the number one priority.	
Sediment accumulation – Estuary and tidal waters –		
Sediment monitoring and characterisation	With the exception of some existing habitat mapping, there is no long-term monitoring for sediment deposition and very little data available on the extent of sedimentation in coastal and tidal waterbodies in the zone. Existing maps suggest that fine sediment deposition is not a large problem where the Ashley River flows into the Ashley Estuary. However, a lot of mud and finer fraction silts are present in the upper reaches of the estuary near such areas as the mouth of Taranaki Creek. Sediment monitoring is recommended to investigate the extent of issue. Sediment traps, particle size analysis, redox state, and other ecological variables should be measured. There is also no detail as to the extent of legacy phosphorus currently bound to estuary sediments.	Even a lack of long-term data, mapping and anecdotal evidence suggests that sedimentation is an issue in coastal water bodies. There remains a question of how much sedimentation in the tidal reaches of waterways is the result of tidal backflow e.g. from the lower Waimakariri River into the lower Kaiapoi River. The big issue here is dealing with the input of fine sediments through controlling CSAs and other diffuse sources. Active sediment removal using dredges cannot be justified (at this point) as the method is hugely disruptive to estuary and tidal ecosystems.
Controlling upstream sources using methods outline above (i.e. "Sediment accumulation – lowland spring-fed waterways)	As well as proximate land sources surrounding coastal and tidal waterbodies, significant sediment inputs are likely to come from the waterways feeding them. Controlling sediment sources in the wider catchment must be employed as per the methods suggested under "*Overland flow pathways of contaminants"* and "*Sediment accumulation in spring-fed lowland streams"*. Sediment inputs may need to be controlled for in both spring-fed and hill-fed catchments. However, spring-fed streams should be prioritised as anecdotal	

Instream measure	Explanation	Other comments
	and limited empirical evidence suggests that flows in the hill-fed Ashley River is significant enough to flush sediment through the Ashley Estuary, not allowing it to accumulate at this point.	
Soluble contaminant inputs (nitrogen) via groundwater – All waterbodies in zone –		
Intercept contaminants using riparian plants, and by creating and maintaining wetlands	The uptake and assimilation of nutrients by riparian and wetland plant species is likely necessary, particularly where contaminant inputs are high. Riparian and wetland planting won't work in gaining reaches where groundwater enters surface channels directly. In these areas, groundwater contaminants bypass riparian buffers. Careful consideration needs to be given around riparian planting strategies (e.g. species, structure etc.) based on preferred function (e.g. habitat creation, shading, bank stabilisation etc.).	Land use management practises are where the "real" solutions occur for remedying high soluble contaminant inputs via groundwater. Instream measures cannot reduce inputs and have a limited capacity for intercepting nutrients for uptake and assimilation. It is assumed that on-farm measures are being addressed under MGM and parallel work streams that go beyond MGM. All evidence suggests that mitigation measures will have to go beyond MGM to meet Waimakariri Zone outcomes for nitrogen. Overall, there are two options over and above interception and uptake. These are to reduce inputs, or dilute them instream. The reality of the situation is that instream solutions will be enough not reach zone outcomes. They will merely assist in reducing a small proportion of groundwater contaminants in a move towards zone outcomes. Catchments with severe nitrate problems (e.g. Silverstream) require huge reductions in surface water nitrogen levels. Consideration must be given to coastal waterbodies situated downstream.
Install bioreactors / denitrification walls	Bioreactors and denitrification walls are currently being intensively researched with some success. Trials are being undertaken in the Waimakariri Zone at the head of Silverstream. Trials are being held elsewhere too (e.g. Waituna Lagoon, Southland) which has seen significant nitrate reductions. However, these techniques are difficult to employ on larger scales and are not likely to be applicable to increasingly diffuse sources. Such methods may be viable for implementation around tile drains and other point source problem areas. Bioreactors and denitrification walls are promising ideas warranting inclusion in the toolbox. But we must be careful as they may have indirect negative effects on other ecological measures. For example, anoxic conditions are favourable for denitrification to occur, therefore a potential downstream effect of using a denitrification wall is the lowered oxygen saturation of stream water and other associated changes in water chemistry. Success is also dependent on the residence time of the groundwater flowing through bioreactors/trenches. They may not be a viable option in areas where nitrate releases to surface water are predominantly due to pulses associated with high rainfall and rapid groundwater movement.	
Macrophyte harvesting	Aquatic plant growth may act as a sink for stream nutrients due to plants uptaking and assimilating biologically available forms of nitrogen and phosphorus. In areas where macrophyte growth is high, plants can be harvested and removed to remove nitrogen	

Instream measure	Explanation	Other comments
	(contained in the plant biomass) from stream systems. Past attempts to measure nitrogen uptake and assimilation in macrophytes have not worked well as macrophytes are often nutrient saturated and don't function efficiently as sinks. Uptake efficiency is also likely to be species-specific. Any improvement in stream nitrogen concentrations resulting from macrophyte harvesting is likely to be minute in nitrogen rich groundwater-fed streams. The management technique is only likely to be a serious option in streams where nitrate levels are considered a lesser issue. Harvesting can also be incorporated in controlling for invasive weed species, although active removal by drain management can be very damaging to habitat.	
Enhance organic matter component instream	The CAREX group at the University of Canterbury is researching the implication of increasing instream organic matter biomass on instream nitrogen. One method they've used is inserting leaf litter bags, but a sustainable alternative would be to increase waterway plantings that naturally shed leaf litter and woody debris into streams. It is unlikely that increasing coarse particulate organic matter instream will substantially decrease nitrate levels, but it may have indirect benefits on other ecosystem functions including the creation of habitat and improving food sources.	
Managed aquifer recharge (MAR) or targeted stream augmentation (TSA)	The instream dilution of contaminants, such as nitrate, should be considered as a low priority compared to reducing inputs and nutrient interception. However, such an option may be inevitable in catchments with extremely high nitrate values both currently and "in the post" e.g. Silverstream. Options for MAR and TSA are being explored in a parallel technical team workstream. Biosecurity risks are present when using methods (particularly TSA) where source water is transferred from one waterbody into another. MAR is likely to have a low surface water biosecurity risk, but groundwater endemism and risks should not be ignored. MAR is also a more culturally acceptable approach than TSA because diverted water is first passed to ground before re-entering targeted surface waterbodies.	
Reductions in stream baseflows and variability, and increased flow intermittency – All waterways in zone –		
Improve stream flow monitoring and modelling	It is very difficult to assess the ecological requirements of waterways in the zone without the expansive modelling and monitoring of	Improving stream flows is explored in parallel technical team workstreams. A zone-wide change to LWRP stream

Instream measure	Explanation	Other comments
	stream catchments. Further development in these areas will benefit the understanding of catchments hydrological behaviours. Establishing naturalised hydrological patterns will help address questions such as: “what is an appropriate (or natural) extent and duration of drying in streams?” This is particularly applicable to the Ashley River which regularly and extensively dries.	depletion rules, minimum flow and surface water allocation revisions, and MAR/TSA options are all being explored. The goal is to provide appropriate environmental flows downstream by ensuring that there is sufficient upstream flow and groundwater levels. This applies to meeting all hydrological measures including improving ecological minimum flows, 7 day Mean Annual Low Flows (7dMALF), flushing flows etc. Adaptive management techniques need to be employed to allow for future changes in climate. We need to think carefully about and consider those streams that aren’t intermittent yet, but are a high risk of becoming so in the future. Flow intermittence functions as a barrier to migration. The longer a reach dries, the more severe the consequence may be to fish recruitment etc. Another suggestion was to engineer refugia pools along reaches of streams and rivers that dry regularly. However, this may result in increased predation and stagnation, and may not stay wetted for long anyhow. One benefit is that they could provide more time for fish rescue efforts. The Eyre, Cust and Ashley Rivers have all been identified as having intermittency issues.
Consent restrictions and reviews	Many streams in the zone are in a state of over-allocation for surface water takes. This effectively means that the time that rivers spend at low flows is prolonged, and flow variability is reduced. Instream communities are increasingly stressed as time spent at low flows increase. A large proportion of water take consents are due to expire between 2030 and 2039 due to long-term consents being granted up to 20 years ago. To reduce over-allocation, new water take consents may need to have greater restrictions, however existing consent terms will likely mean that over-allocation will persist for some time yet. This means that some, if not all, consents may need to be reviewed to allow for claw back.	
Create, restore and maintain wetlands	Wetlands act as sponges by effectively holding onto water and slowing residence times. This allows for the slower release of water to surface channels and improves the maintenance of base-flow conditions. Existing wetland maintenance and protection is important. The creation of new wetlands is a much more difficult task. Wetland creation has a sketchy track record and lack proven success due to the difficulty of manufacturing appropriate hydrological regimes.	
Stream augmentation from storage	Water storage in the head of catchments will allow scope for the provision of environmental flushing flows. A significant proportion of stored water would need to be allocated for environmental purposes. The relative importance of environmental flow releases also changes with time and key fish migration periods.	
Managed aquifer recharge (MAR)	MAR is an area of extensive research, particularly in the Hinds area south of Ashburton. This study has had mixed results thus far. MAR can be applied at both the on-farm and catchment-scale level. It has other benefits, such as diluting stream contaminants, but must still be considered a low priority compared to improving water use through appropriate allocation, and improved land management actions such as improving	

Instream measure	Explanation	Other comments
	irrigation efficiency (i.e. how and when to irrigate).	
Targeted stream augmentation (TSA)	TSA is less desirable than MAR due to being cultural unacceptable and having increased biosecurity risks. TSA also has implications for increasing sediment if sourced from highly turbid waterbodies such as the Waimakariri River. See "*Soluble contaminant risks via groundwater sources*".	
Input of urban stormwater contaminants – Spring-fed and tidal waterbodies –		
Upgrade old and inadequate stormwater systems	Kaiapoi and Rangiora are recognised as old towns with areas that require upgrades to older infrastructure. Leaky sewerage systems and sewerage overflows are examples of surface water contamination sources resulting from inadequate stormwater systems.	Largely this is an issue that will be dealt with by the local councils that own and maintain urban infrastructure.
Public education and advocacy	Effective education programmes need to inform the public of what not to wash into their stormwater drains. Many people don't realise that stormwater networks are directly connected to streams and rivers.	
Source treatment and control	Urban sprawl continues within the Waimakariri Zone and with increased population growth comes increasing levels of urban contaminants entering waterways. Stormwater treatment at the source may be a necessary control that is required moving forward. This means treating stormwater at downpipes, sumps and swales at individual properties before it enters the stormwater network. Research continues in this area, but requires further work and understanding. Technologies require further development.	
Reduced indigenous biodiversity resulting from habitat loss – All waterbodies in zone –		
Physical habitat monitoring	Information gathering is required on the current state of physical stream habitats and the effectiveness of implementing measures for rehabilitation. Currently there is a very limited instream habitat monitoring in State of the Environment (SOE) programmes. Monitoring should measure habitat diversity, channelisation, straightening, run/riffle/pool sequences, woody debris, sediment, riparian planting and other variables.	Instream habitat quality and diversity are not necessarily the same thing. Typically, an increase in habitat diversity will result in an overall increase in reach-scale habitat quality. However, sometimes increasing habitat quality may not necessarily mean increasing habitat diversity. For example, removing legacy sediment from a waterway that contains solely run habitat will improve habitat quality, but will only retain one habitat type and not improve habitat diversity.
Establish suitable minimum flows and allow for flow variability in waterways	The appropriateness of minimum flows and surface water allocations in the zone are addressed in a parallel technical team workstream. Methods for ensuring appropriate	

Instream measure	Explanation	Other comments
	minimum flows are suggested under "*Reductions in stream baseflows and variability, and increased flow intermittency"*. Ecological minimum flows serve a multitude of purposes. These include ensuring liveable habitat availability, fish passage for migration, and fish spawning habitat. Not only is the magnitude of a minimum flow important for habitat protection, but so too is the duration a stream spends at or below minimum flow levels. Aquatic species experience high stress under low flow conditions, therefore there is a need for streams to experience significant flow variability. Flushing flows remove algae and sediment, which may smother habitat if allowed to persist under stable conditions. They also connect waterways that dry extensively in patches, and act as barriers to fish passage.	
Reduce streambed sediment by reducing sediment inputs and removing legacy sediment	Deposited sediment has extensively degraded spring-fed stream habitat quality in the zone. Sediment fills the interstitial spaces between gravels and rocks, and smothers the stream bed where aquatic fish and invertebrates live. Sedimentation should be addressed as per the options highlighted under "*Sediment accumulation in spring-fed lowland streams"*.	
Improve riparian planting	Good riparian planting and maintenance has a host of benefits for instream ecosystem health. Benefits include: habitat provision, stream shading, bank stabilisation and reduced erosion, reduced sediment inputs, improved organic food matter, increased instream woody debris, the filtering of contaminants, and riparian habitat provision for birds and other terrestrial species.	
Increase amount of instream woody debris	Improving the number of instream coarse woody debris will provide habitat to instream fauna. A self-sustaining way to achieve this is by planting woody riparian species.	
Address channel straightening and modification	Many streams in the Waimakariri Zone are extensively channelised and straightened. Engineering a greater level of sinuosity and promoting changes in flow profiles will help achieve more "naturalised' waterway states. Increased habitat diversity should be encouraged by creating diverse riffle, run, and pool habitats. Bank contouring and rebattering will promote bank stability, and reduce collapse and sedimentation.	
Monitoring and effective enforcement concerning braided river encroachment	Aquatic habitats in braided river plains range from the highly disturbed main channels and side braids to stable, groundwater-fed, spring	

Instream measure	Explanation	Other comments
	creeks ponds and wetlands. Despite being a single waterbody, there is a stark contrast in physico-chemistry between water in the main channels and the lateral habitats. Ecological studies have found that despite their proportionally smaller wetted area, the stable lateral habitats consistently have a greater number of aquatic species and abundance of individuals than main channels. Lateral habitats contain a considerable proportion of the ecological value of braided rivers and provide a source of re-colonists to the disturbed channels post flood. However, these habitats and consequently the ecological structure and function of braided rivers overall are threatened by various pressures. Braided river encroachment needs to be prevented using effective plans and other regulatory frameworks. As it stands, current protection extends to alpine-fed braided river plains of which the Waimakariri Zone has none. However, the Ashley River (and some others) does share some similar characteristics and it could be considered appropriate to subject it to encroachment rules. The effective monitoring and enforcement of rules is important to ensuring effective river protection.	
Barriers to fish passage – All waterways in zone –		
Identify and prioritise areas for remediation	The extent to which barriers to fish passage exist within the Waimakariri Zone is poorly understood. On-the-ground investigations are required to document the location of fish barriers, followed by a prioritisation of barriers to be remedied based on catchment and species values.	When considering fish barrier mitigation, it is important to consider what values we are protecting and where. Important sports fisheries may require the remediation of all barriers to preserve recreational value. However, in high-value native fish habitats, it will likely be important to maintain some barriers for predatory species such as salmonids. Such areas will include those where non-migratory mudfish populations reside (e.g. Mounseys Stream).
Retrofit weirs, and tide and flood gates to readily allow for fish passage	Tide and flood gates are a common feature in the lower reaches of many zone streams. Examples include Waikuku Stream, Taranaki Creek, Courtenay Stream, Kairaki Stream, McIntosh Drain, and tributaries of the Cust and Cam Rivers. Tide and flood gates are an effective barrier to fish passage and can be particularly problematic during key migration periods. Engineering and retrofitting tide and flood gates with fish passage mechanisms should be investigated and employed. The same applies for weirs.	
Remedy inadequately designed culverts	Fish passage guidelines exist and outline the requirements for new culvert designs in streams. These include considerations for culvert length, gradient and positioning, water velocity and depth, and timing for undertaking stream works. Culverts that do not meet guideline recommendations in the zone should	

Instream measure	Explanation	Other comments
	be identified and remediated to an improved standard.	
Utilise alternative barrier mitigations	Alternative options are available for mitigating fish barriers that do not allow for fish passage. These may be considered for us when replacing or remediating a culvert or weir is not a viable option. Methods include the use of mussel spat ropes, rock ramps and baffles. Each method provides a medium for fish to climb, however some are more suitable for some fish species than other.	
Replace inadequate fish screens	Inadequate fish screening on water intakes allows for fish passage (when not desired) and can lead to increased fish mortality rates. Fish screens that do not meet appropriate industry standards need to be located and replaced. Ensuring compliance and maintenance are also important components of guaranteeing effective fish screening.	
Ensure minimum flows and flow variability are sufficient to reduce anthropogenic intermittence in waterways	See "*Reduced indigenous biodiversity resulting from habitat loss*".	
Reduced indigenous biodiversity resulting from pest and weed species – All waterbodies in zone –		
Weed clearing by drain management	Identifying and targeting invasive weed species to allow non-pest species to proliferate. This involves educating river engineers, farmers and others conducting drain clearance activities about what aquatic plant species are invasive pests and those that aren't. Caution must be employed as drain clearance can be detrimental to other ecosystem values. Digging and dredging often leads to instream habitat damage, fish kills, channel damage, and sediment disturbance.	Didymo is assumed to be of no issue for the Waimakariri Zone. Instream biodiversity in this case is referred to as a combined measure of both species abundance and diversity.
Willow and other pest riparian species management	Implementation of riparian pest management plans for the ongoing control of problem areas. Species include (but are not limited to) yellow flag iris, willow, gorse and broom. Pest plants growing in the beds of braided rivers can restrict the braided nature of flow paths.	
Terrestrial weed management to improve river bird life	Terrestrial weed management using manual removal and chemical (e.g. herbicides) treatments should aim to improve habitat for river bird foraging and nesting. However, Runanga are often concerned with traditional methods.	
Cyanobacteria management	What causes potentially toxic cyanobacteria blooms is an area of ongoing research.	

Instream measure	Explanation	Other comments
	Growths pose a significant risk to human and animal health, and is a significant problem for the recreational and aesthetic health of waterways such as the Ashley and Cust rivers. Controlling cyanobacteria growth should be addressed through appropriate nutrient management techniques and by providing for increased flushing flows. See "*Reductions in stream baseflows and variability, and increased flow intermittency*","*Soluble contaminant inputs via groundwater*", and "*Overland flow pathways of contaminants*".	
Investigate and manage any invasive fish species	There is uncertainty about the state of pest fish communities in the zone. The Kaiapoi Lakes are known to contain coarse fish species (e.g. rudd, tench, perch, karp and/or other cyprinids), however the issue is likely to be small when compared to North Island waterbodies. Viable breeding populations are unlikely to exist as environmental conditions are not favourable. This could change with water temperature increases associated with climate change. Investigations should improve the information on the extent of pest fish, and whether there is a capacity for fish move into other waterbodies.	
Climate change – Coastal and tidal waterbodies –		
Managed coastal retreat	Managed coastal retreat is essentially "letting it do its own thing". The alternative is to battle coastal retreat in which case the intertidal area will become increasingly constrained. The greatest opportunity for ensuring protection is to give estuarine environments space by implementing coastal zoning rules (i.e controlling what land can be used for). This will include retiring land around estuary margins, of which Environment Canterbury owns much of and leases to grazing. The Kaiapoi Red Zone could also be managed. Managing the margins of coastal waterbodies can also improve habitat and other ecological values, but will not control for the vast majority of contaminants entering from the wider catchment.	Increased salinisation of freshwaters in the lower reaches of streams and rivers will occur with increasing sea level rise. It is best to accept and acknowledge that this process will occur and therefore begin managing for it now.
Adaptive management to protect and provide for habitat change	As sea levels rise, marginal coastal and freshwater habitats will shift. Of particular importance will be protecting and managing for shifts in inanga spawning habitat. Spawning habitat will progressively move inland to increasingly upstream areas. In their current state, such areas may contain hard surfaces and other environments unsuitable for inanga to lay eggs. Adaptive management plans should be proactive and protect these areas from further development. Desktop exercises	

Instream measure	Explanation	Other comments
	will be able to map areas of concern using modelled predictions for sea level rise.	
Climate change – Hill and spring-fed waterways –		
Adaptive management of water allocation limits and restrictions	What happens if stream flows, groundwater levels, and land surface recharge decrease with climate change yet water allocation remains the same? Allocation will make up a larger proportion of stream flows, which will have a detrimental effect on instream ecosystems. Hydrological management approaches will be required to continually adapt and follow changes in climatic conditions. This will mean clawing back allocation as stream flows drop, and giving "back" to the environment (i.e. not re-allocating). See "*Reductions in stream baseflows and variability, and increased flow intermittency*".	Many hydrological models predict decreases in stream baseflows as climate change progresses. However, there remains the question of how will predicted increases in extreme weather events (both drought and flooding) impact instream ecosystems? It is important to consider biodiversity risks. As temperatures increase, species ranges can expand or contract. Previously unliveable areas could become liveable for certain biota.
Increased water use efficiency including irrigation methods	Irrigation management will need to continually adapt and improve in response to climate change. This will mean continually researching and implementing techniques for irrigating land appropriately, e.g. not over-applying water to land when soil moisture levels are optimal. The advanced education of water users, both rural and urban, will be required.	
Managed aquifer recharge (MAR)	Importing water from external sources to address predicted declines in stream base flow conditions. When employing methods such as MAR and TSA, it is important to consider the effects on flooding in downstream reaches, particularly if extreme weather events are predicted to become more common (i.e. high rainfall events). See *"Reductions in stream baseflows and variability, and increased flow intermittency"*.	
Targeted stream augmentation (TSA)	Importing water from external sources to address predicted declines in stream base flow conditions. When employing methods such as MAR and TSA it is important to consider the effect on flooding in downstream reaches, particularly if extreme weather events are predicted to become more common (i.e. high rainfall events). See *"Reductions in stream baseflows and variability, and increased flow intermittency"*.	
Increase soil moisture retention capacity	Increasing soil microbes and organic matter (carbon) content in the ground may help improve the moisture retention capacity of soils. This would lessen the need to apply	

Instream measure	Explanation	Other comments
	greater quantities of water to land as soils will remain wetter for longer. However, it is likely to be difficult to increase the amount of carbon in soils via purely natural biological pathways. The carbon content in soils tend to stabilise over time (excess is given off as CO2 due to soil respiration). A potential alternative would be to somehow increase soil depth and therefore increase the overall storage capacity for organic matter.	